Perchlorate Treatment Technologies

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Agenda

- Safe Drinking Water Act Requirements
- Compliance Options
- Treatment Technologies
- Questions

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Safe Drinking Water Act Requirements

- The Maximum Contaminant Level (MCL) is set as close as feasible to the Maximum Contaminant Level Goal (MCLG)
- The feasible level is determined using the best technology, treatment techniques, and other means that are available
  - Examines for efficacy under field conditions (not solely under laboratory conditions)
  - Takes cost into consideration
- List treatment technology and techniques capable of meeting an MCL referred to as Best Available Technologies (BAT)
- Also lists Small System Compliance Technologies (SSCT)
  - SSCT are technologies that achieve compliance with the MCL and that are determined to be affordable for small systems

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Best Available Technologies (BAT)

- EPA evaluates the following criteria to identify BAT:
  - Capability for high removal efficiency;
  - A history of full scale operation;
  - General geographic applicability;
  - Reasonable cost (for large systems);
  - Service life;
  - Compatibility with other water treatment processes; and
  - Ability to bring all of the water in a system into compliance.

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Small System Compliance Technologies (SSCT)

- In addition to the criteria for BAT's, EPA also evaluates the following criteria for SSCTs
  - Affordability of the treatment at households in systems serving
    - 25- 500 people
    - 501 – 3,300 people, and
    - 3,301 – 10,000 people
- Considers packaged or modular systems, and point of entry (POE) and point of use (POU) systems

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Treatment Technologies


Anion exchange (AX)


Biological treatment


Reverse osmosis (RO)


Point-of-use reverse osmosis (POU RO)

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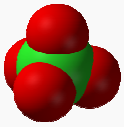
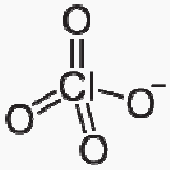
Perchlorate Anion



- Inorganic Ion, $\mathbf{ClO_4^-}$
- Occurs as Perchlorate salts
  - Ammonium Perchlorate, $\mathbf{NH_4ClO_4}$
  - Perchloric Acid, $\mathbf{HClO_4}$



- Highly soluble, dissociates completely
- Conventional treatment will not remove it

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Ion Exchange Technology

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Ion Exchange Vessel

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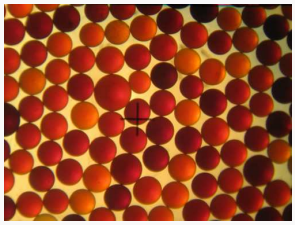
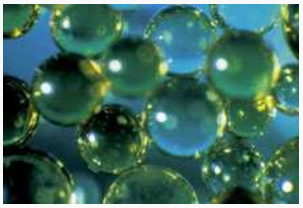
Ion Exchange Resins





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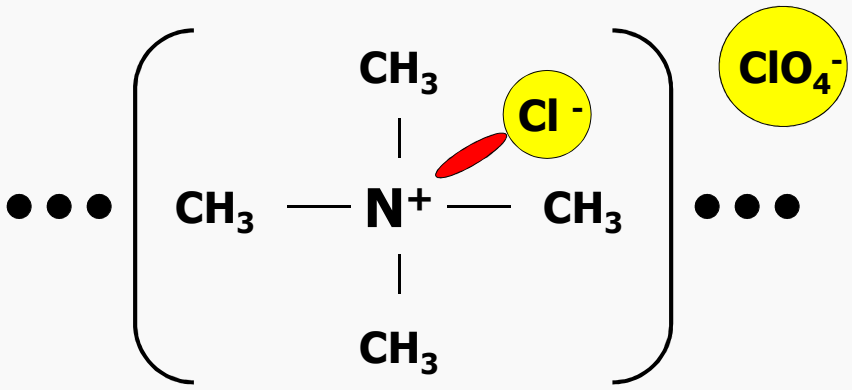
Anion Exchange Resin



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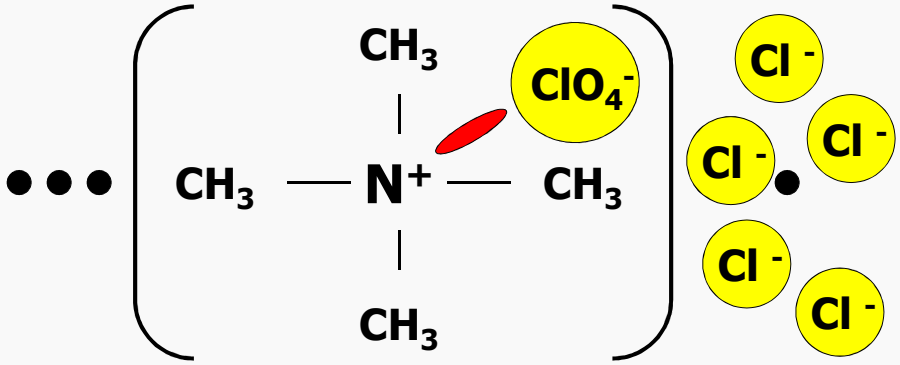
Anion Exchange Resin



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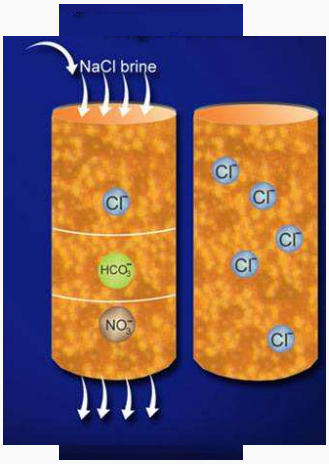
Anion Exchange – Process Overview

- Resin Capacity (Bed Volumes)
- Resin Affinity
  (Perchlorate vs. other anions)
- Disposal vs. Regeneration



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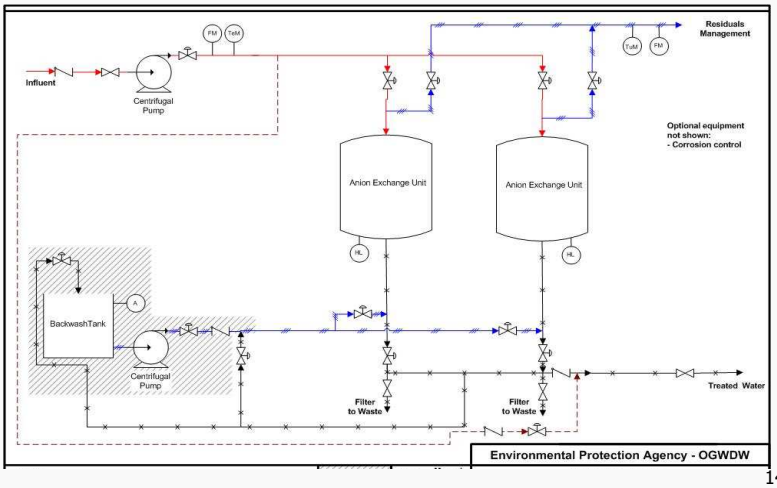
Anion Exchange with Resin Disposal



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Effective Anion Exchange Resins

- Perchlorate Selective Resins
- Nitrate Selective Resins
- Strong Base Anion Exchange Resins
- Weak Base Anion Exchange Resins

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Perchlorate Selective Resin

Advantages

- Very High Affinity for Perchlorate
  - Limited sensitivity to competing anions
  - can remove perchlorate to below 4 µg/L
- Bed Volumes
  - Ranging from 100,000 to 170,000 Bed Volumes
  - Longer run-times, less residuals generated and lower operating cost than other resin types

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Perchlorate Selective Resin

Disadvantages

- Resin regeneration is difficult
- Resin is generally disposed
- Disposal
  - Co-contaminants might affect final disposal options
  - Generally disposed at non-hazardous disposal facilities

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System Level Costs - Anion Exchange

Population Served	Total Capital Costs	Operation and Maintenance Costs
25 – 500	$150,000	$6,000 / yr
501 – 3,300	$400,000	$25,000 / yr
3,301 – 10,000	$1,500,000	$100,000 / yr
10,000 – 50,000	$3,000,000	$300,000 / yr
50,001 – 100,000	$6,500,000	$1,000,000 / yr

* O&M Costs include residuals disposal

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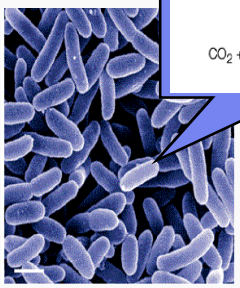
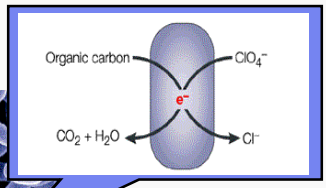
Biological Treatment

- Perchlorate reducing bacteria destroys Perchlorate by chemical reduction
- Effective Process use:
  - Fluidized Bed Reactors
  - Fixed Bed Reactors





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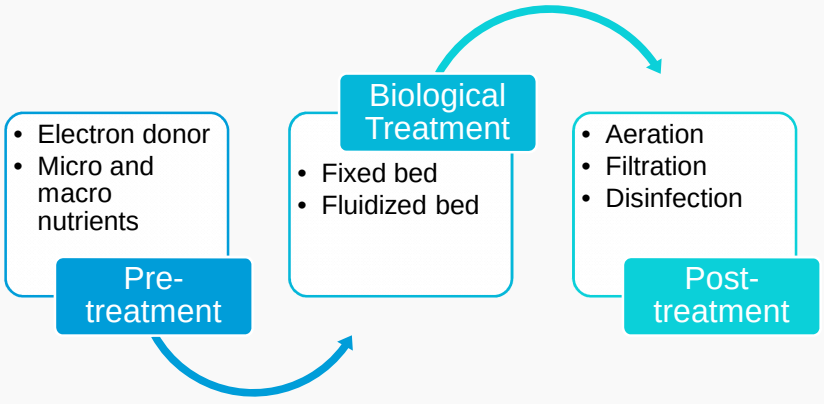
Biological Treatment Steps



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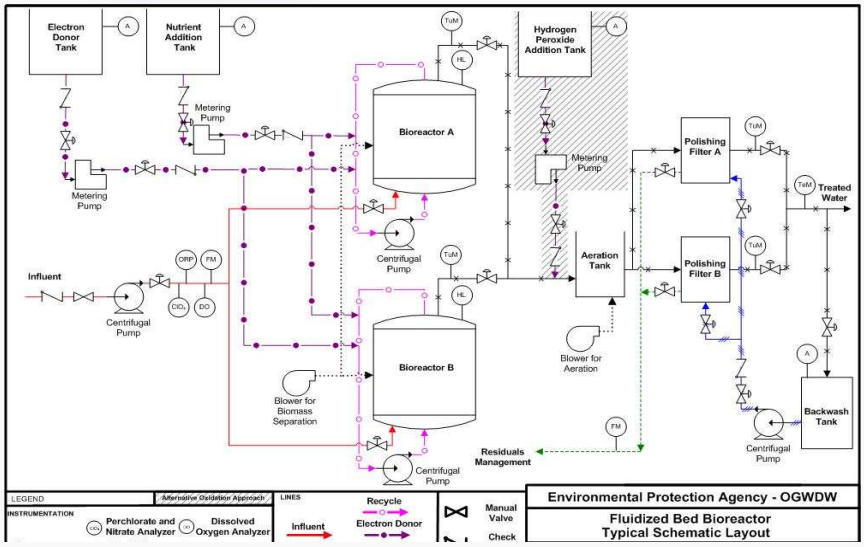

Advantages and Disadvantages

- Advantages
  - Reducing bacteria destroys Perchlorate
  - Demonstrated to remove perchlorate below 4 µg/L
  - No Perchlorate in waste/residual stream

- Disadvantages
  - Requires pre- and post-treatment water adjustments
  - Water temperature must be kept above 10ºC for biomass growth
  - Operational complexities
  - State implementation requirements and public perception might be impediments

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System Level Costs – Biological Treatment

Population Served	Total Capital Costs	Operation and Maintenance Costs
25 – 500	$1,000,000	$40,000 / yr
501 – 3,300	$2,00,000	$100,000 / yr
3,301 – 10,000	$5,000,000	$300,000 / yr
10,000 – 50,000	$9,500,000	$750,000 / yr
50,001 – 100,000	$18,000,000	$1,500,000 / yr

* O&M Costs include residuals disposal

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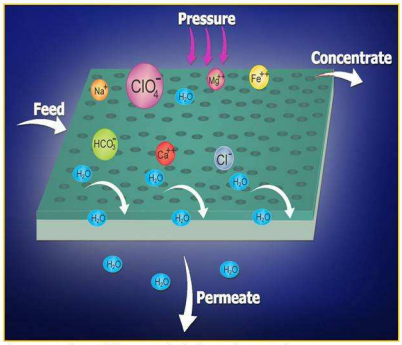
Reverse Osmosis – Membrane Filtration



(Figure Adapted from Gabelich et al., 2001)

- Semi-permeable membrane removes Perchlorate
- Water passes through the membrane
- Dissolved and suspended solids are rejected by membrane (steric exclusion)

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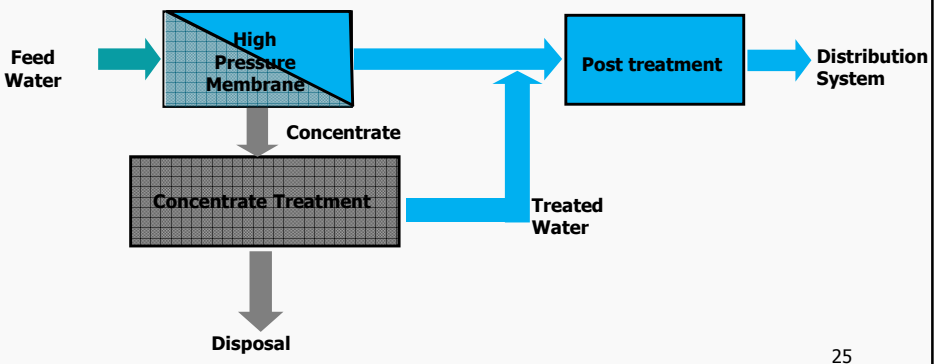
Typical Reverse Osmosis Process



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Advantages and Disadvantages

- Advantages
  - >90% perchlorate removal
  - Removes most co-contaminants
  - Well known / Proven technology
- Disadvantages
  - High capital and operating costs
  - Large residual stream (up to 30% of raw water)
  - Less practicable for systems facing water scarcity/shortages

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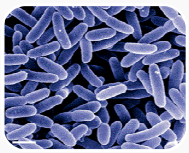
Reverse Osmosis Residuals Disposal Options

POTW

Deep well injection



Biological treatment

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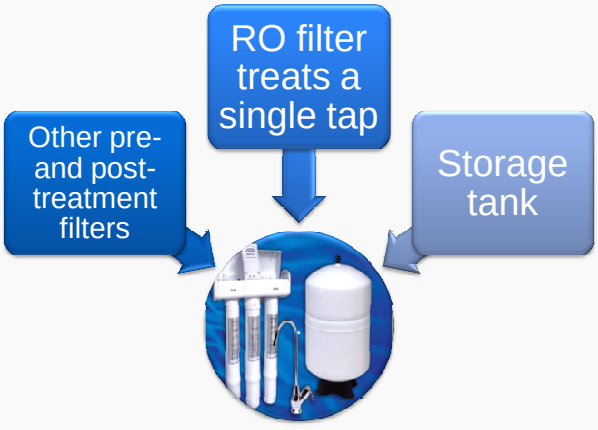
Point-of-Use Reverse Osmosis



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Advantages and Disadvantages for POU

- Advantages
  - Economical option for small systems
  - >90% perchlorate removal
  - Removes most co-contaminants
  - Residual discharges to sewer, septic system
  - Treats small portion of household consumption (at tap)
- Disadvantages
  - Not all states allow POU devices
  - System must be owned, controlled, and maintained by the water system or by a person under contract with the water system
  - Customer participation

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System Level Costs – Reverse Osmosis POU

Population Served	Total Capital Costs	Operation and Maintenance Costs
25 – 100	$10,000	$5,000 / yr
101 – 500	$60,000	$15,000 / yr
501 – 1,000	$140,000	$45,000 / yr
1,001 – 3,300	$350,000	$100,000 / yr

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Modified Granular Activated Carbon (GAC)

- Performance Review:
  - Most of bench and piloting work prior to 2006
  - No performance data on a full-scale demonstration
  - Not aware of peer reviewed information that would enable listing as a BAT or SSCT

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Summary

- EPA is evaluating technologies for listing as BATs and SSCTs
- EPA is currently considering available data (efficacy and cost) for listing
  - Anion Exchange,
  - Biological Treatment, and
  - Reverse Osmosis (both centralized and POU)

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